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NOTES ON THE TRANSFORMATIONS OF HIGHER HYMENOPTERA.—III.

BY A. S. PACKARD.

Megachile (possibly *centuncularis* Linn.).

Larva.—Head of the usual proportions, of good size compared with the rest of the body. Eye-pieces prominent, full and convex. Towards but below the vertex, in between the eye-pieces, is a depressed subcordate area, with a subacute depressed tubercle on each side of the median line, which may be the antennæ; between this area and the clypeus is a transverse raised portion; on each side of this ridge and aligned with the side of the labrum at its base is a minute corneous tubercle, which may be the antennæ, though I think not.

The clypeus is considerably shorter than broad; its base is a little subacutely produced onesidedly, the front edge deeply excavated; the surface is not convex and increases in width towards the anterior edge. The labrum is broadly subtrapezoidal, twice as broad as long; base rounded, semi-circular; anterior edge rather deeply excavated, rendering it slightly bilobate. Mandibles slender, not narrowing much towards the end, which is unequally bidentate, the inner tooth the smaller; they are much broader, stouter and thicker at the end than in *Andrena*.

The maxillæ are long and slender, acutely pointed at the tip on one side, the inner lobe being produced and incurved, while the outer acute lobe or tubercle is minute; this is easily overlooked and more remote from the other lobe than usual; they are long enough to touch each other. The labium is long, square at the end, corneous; below and posterior to this square corneous or chitinous edge are two minute acute spines on each side of the labium, which are probably the rudimentary labial palpi.

The body is thickest towards the posterior end, on the terminal fifth of the body, whereas in *Andrena* it is thickest at about the middle; towards this last fifth the body gradually increases in thickness, and then suddenly rounds off, so that the end is much rounder, more obtuse than in *Andrena* and the larva of Apidæ in general. The penultimate sternite is larger and broader than in *Andrena*, while the last sternite is smaller; differences readily appreciable. On the whole the larva of *Megachile* resembles that of *Bombus* more than that of *Andrena*.

As regards the head characters, the larval *Megachile* differs from the

larva of *Andrena* in its head being a little larger, the antennal tubercles being flatter and much less prominent; the eye-pieces less globose and spreading less laterally. The clypeus is longer and larger, and the front edge deeply excavated, where in *Andrena* it is square and entire. The labrum is narrower, the front edge more excavated, being hardly at all so in *Andrena*. The mandibles are stouter; the maxilla large and slender, as is the labrum, which has a broad, thickened, square chitinous tip, not present in *Andrena*, the end of which in *Andrena* is fleshy.

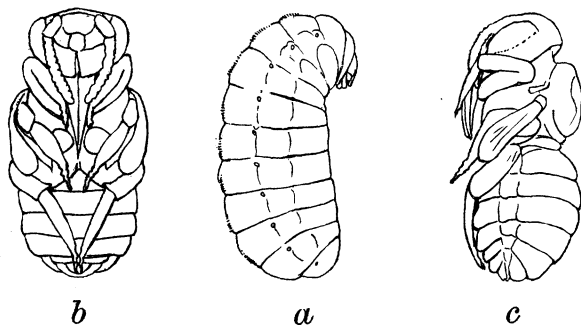


Fig. 9. *Megachile centuncularis*. a, larva; b, c, pupa. (Emerton, del.)

Pupa.—Head broad and flat, subtriangular, the front flattened; the supraantennal area broad and flat; seen laterally the head is much more vertical than in *Bombus*, and is more like *Apis*; seen from above the head is much broader, supraclypeal piece transversely oblong-triangular, thus setting the antennæ far apart. Clypeus transverse, broader than long, with two curvilinear lateral lobes which are much longer and more curved than in *Bombus*. Labrum square, longer than broad, the edges square, the sides contracting slightly towards the anterior edge, which is square, not rounded or excavated. Mandibles long, stout, thick, not incurved, but rather bent inwards so as to meet just in front of the labrum. The eyes are more prominent and farther apart than in *Bombus*. Antennæ more rectangularly bent than in *Bombus* owing to the greater width of the head; the joints are shorter, much more convex; only reaching to just beyond the middle of the anterior tarsi, whereas in *Bombus* they reach to the second joint of the posterior tarsi. The maxillæ reach just beyond the anterior tarsi; neither pair of palpi are visible. Paraglossæ extending to half-way between tips of lingua and the maxillæ. The mouth parts are less loosely arranged on the breast than in *Rhopalum*, *Pelopæus* and the other fossorial forms.

The legs are very short compared with those of *Bombus*, only the last pair meeting, the terminal joints of the tarsi folded together and lying contiguous to each other; tarsi much shorter and thicker than in *Bombus*.

Abdomen broader and squarer, more truncated at tip than in *Bombus*, the terminal urites as in *Bombus*; the rhabdites nearly retracted, forming a pair of papillæ which are rounded and thick.

The body is less curved on itself and the prothorax shorter. The mesoscutellum is less prominent and convex, while the abdomen is longer and narrower; the segments more thickened at the end, and spined more prominently.

The tegulæ are, as in *Bombus*, divided into an anterior flattened area, on the side of which, just above the pleurites, are the spiracles, and a posterior raised thickened area on the posterior half of the segment, which is much flatter, less ridged and convex than in *Andrena*, resembling *Bombus* more in this respect; this flattened ridge widens more towards the pleurites. The pleural region with elevated thickened tubercles, a separate knob on each segment. The ridges on the tergites and pleurites are no more distinctly marked on the prothorax than elsewhere, and not, in fact, so much as on the abdomen. Beneath the sternites are a little more ridged, more convex than in *Andrena*. The whole surface above and beneath is covered with minute hairs, which are absent in *Andrena*.

The pupa can at once be distinguished from that of *Andrena* by the prothoracic segment not being thickened any more and not quite so much as the abdominal ones, by the head being a little larger, and by the body not so rapidly tapering towards the head, and being thickest on the posterior one-fifth.

In all these characters *Megachile* closely approaches *Bombus*. In the head-characters it closely resembles *Bombus*; the clypeus, however, is not so small and distinct, and the labrum is a little larger, and less distinctly bilobate, while also the supraclypeal area is quite different, not being so triangularly depressed; posteriorly the shape is much the same. The labrum differs in the tips being rounded, fleshy, and with a terminal lunate area. The maxillæ are more acute, terminating in longer spines. The body is broader and flatter, the pleural region a little more prominent, and the terminal segment quite different, the tergite being much smaller than the sternite; which is very different from that of *Bombus*. *Megachile* does not have the minute thoracic tubercles ending in minute spines present in *Bombus*; the thickenings of the rings posteriorly are more marked in *Megachile* than in *Bombus*, and the body is more hirsute.

***Ceratina dupla* Say.**

Larva.—The following description was drawn up from living specimens.

Head rather long and narrow, as in *Megachile*; full and convex; the vertex elevated convex, with fine hairs; front scarcely so broad as in *Megachile*. Clypeus full, convex. Labrum exserted, square, thick and very prominent; end much thickened, excavated beneath. Mandibles as in *Megachile*, long and thick, suddenly bent in under the labrum, so that the tips are not visible. Antennæ rather thick, bent at a considerable angle on the side of the clypeus; the scape longer and slenderer than in *Megachile*, the flagellum a little clavate, the tips reaching to the end of the maxillary palpi, or near the tips of the first tarsal joint when the leg is normally folded. Ocelli similar to those of *Megachile*, forming raised, acute papillæ; the maxillæ are nearly twice as long as in *Megachile*, reaching to the middle of the body and to the second pair of trochanters. The palpi three-jointed, rapidly tapering toward the tip; the basal joint much the largest. Labial palpi two-jointed, reaching to the tip of the second pair of legs; lingua long and slender, like that of *Bombus* in length, reaching to the

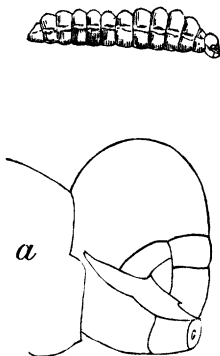


Fig. 10. *Ceratina dupla*. Larva; a, head enlarged. (Trouvelot, del.)

tip of the second abdominal segment. The legs much slenderer than in *Megachile*, the tarsal joints especially slenderer and longer than in *Megachile*, and reaching the same relative distances toward the tip of the body. In the median line of each of the second to the fifth abdominal segments is an acute spine, the hind tarsal joints lying on each side of and parallel with them; these spines I have not before noticed. The last sternite is full and large, rounded triangular. The ovipositor

is exerted, the rhabdites, as usual, forming a square tip. The thorax above is much as in *Megachile*, but the abdomen is more contracted at base, and a little more acutely produced at tip, but otherwise much as in *Megachile*; the edges of the abdominal segments are posteriorly much thickened and minutely dentate. Length, .30 inch.

It differs from *Megachile* in its longer, narrower head, narrower full clypeus, the shorter, squarer labrum, the long lingua and maxillæ, the latter being nearly twice as long as in *Megachile*, also in the presence of the four acute spines along the under side of the abdomen, as well as in the longer, slenderer legs and the narrower base of the abdomen.

***Xylocopa virginica* (Drury).**

Larva.—Received July 8 from M. James Angus, of West Farms, N. Y.

Length, 1 inch; thickness, .28 inch. Larva nearly full grown. The head is very small, and the jaws move rapidly, being thrust out back and forth from beneath the labrum, which is very movable. Body cylindrical and tapering to a point, so as to be very much alike at both ends. The usual lateral swollen area is very faintly marked, rendering the body still more cylindrical than usual. The segments of the body are quite convex, the sutures being rather deeply impressed, but they are not tuberculated above, though somewhat thickened on the hinder edge.

The larva is much like that of *Bombus*, but slenderer and tapering more towards each end.

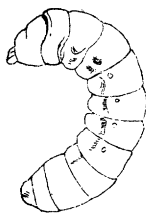


Fig. 11. *Xylocopa virginica*. Larva natural size. (Emerton, del.)

***Anthrax sinuosa* Wiedermann.**

Larva.—We received July 8, 1867, from Mr. James Angus, the larva of this species (see Guide to Study of Insects, 397), but have not published the following description: Body smooth, flattened, slowly tapering towards each end, so that it is difficult to tell which is the head or tail end. The head is oblong, with the jaws on the under side, re-

tracted. The segments above not very convex, though the sutures are very distinct and well impressed. Laterally they dilate into a large subacute tubercle. The end of the body is smooth, rounded, subacute. There are no hairs. Color dusky, white on the head and end of the body. Length of body; .20; width, .05 inch.

Bombus fervidus.

Nesting-habits, Larva and Pupa.—The nest and young of this species, together with the bees, were found by Mr. F. W. Putnam, at Bridport, Vt., August 5, 1863. The nest occurred with several others under the grass in deserted mice nests. There were only three imago bees in the nest, as it was collected at noon time when the rest of the colony was out. One bee, however, left its cell soon after the brood was collected.*

All the workers, sixty-five in number, had escaped from their cells and deserted the nest, the brood-cells having had their upper third irregularly eaten away. The bodies of four or five workers remained in certain cells in which they had died. I have never found any traces of ichneumon parasites in any *Bombus* nest.

Dimorphic Forms.—The colony also contained 13 males, 5 small and 8 large individuals; also 9 queens, of which 3 were small and 6 large. The measurements were as follows:

Average length of 4 workers with the hair all grown, .55 in.; breadth, .35 in.

Average length of 3 females, with the hairs just beginning to grow, .62; breadth, .38 in.

Average length of 6 females, naked and white, .67; breadth, .43 in.

Average length of 5 males, dark and hairy, .52; breadth, .30 in.

Average length of 8 males, naked and white, .55; breadth, .33 in.

From this it will be seen that there are two sizes of males and two of females, among bumble bees. Whether this holds good for the workers must be proved by further observations.

In the two sets of males and females there was as much variation in length between the individuals as between the two sizes taken collectively. The difference in size between the smallest males and females was .10 inch, and the difference in size between those of the larger set was from .01 to .12 inch; the difference in size between the smallest male and the largest female was .25, being .3 more than one-half the length of the smallest male.

* Also see notes on the habits of some species of bumble bees, by F. W. Putnam. Proc. Essex Institute, IV, October, 1864, 98-104.

Of the first brood of males and females the latter were not nearly so dark and hairy as the males, which were just ready to leave their cells, except one which was a subimago.

I first observed this dimorphism in the pupæ taken from this nest; it was better seen than in examining the adult bees.

The eggs are elongated cylindrical, with the ends truncated and rounded off; and they are slightly curved in themselves.

Larva of Worker.—In their general form the larvæ of *Bombus* agree closely with those of *Apis* and *Megachile*. In outline lunoid the body is thick, cylindrical, though a little flattened, and the rings rapidly diminish in width towards each end of the body. In their natural attitude the larvæ when in their cells are doubled upon themselves, so that the under side of the head is closely oppressed to the tip of the abdomen. The enlarged pleural surface, which forms a raised lateral ridge, aids in giving the flattened appearance to the body. On the hinder half of each ring of the body is a tergal raised, flattened band proceeding on each side from the lateral ridge, leaving a transverse depressed ovate lanceolate area, at each end of which is a spiracle. There are ten spiracles, one for each thoracic ring and one on each of the first seven abdominal rings.

Beneath the body is flattened, and the sternal region is very distinct from the raised pleuræ. Each ring has its surface raised into two transverse ridges.

Above, the thoracic rings differ from the abdominal ones in having the raised portions cover nearly the whole surface, which actually takes place in the prothoracic ring. It is on this raised portion that the minute horny acute papillæ are situated; two for each second and third ring, and three on the middle of the prothoracic ring in a transverse line. The arrangement of these tubercles does not essentially vary in the different species. The prothoracic ring is a third narrower than in the metathoracic ring, though as long. The tenth and abdominal ring is in outline equal in size to that of the head, being orbicular when seen from behind. Its surface is marked below by an oblong square raised mesial portion, twice as long as broad. There is no anal outlet since the intestine is a blind sac. The ♂ and ♀ genitals can be distinctly seen, so that the sexes of the larvæ can be easily distinguished.

Of the two pairs of stylets on the ninth ring, the most basal and outer are triangular, and the inner sides nearly meet over the mesial line of the body. The smaller outer and more remote pair have their greatest length across the ring; their tips nearly meet on the mesial line of the

body and near the tips of the middle pair of stylets. The pair of the eighth ring is later developed. They appear first as two oval rings remote from the middle, and larger axes at right angles to body. Early in the semipupa stage, when they first appear as two slender elongated stylets, lying across the eighth ring, with square bases facing each other on each side of the mesial line of the body, while the ends look outward towards either side of the body, at this time the mesial pair or true ovipositer on the ninth ring is long and slender, while the outer pair have only their triangular tips developed, which slightly converge toward tips of second pair.

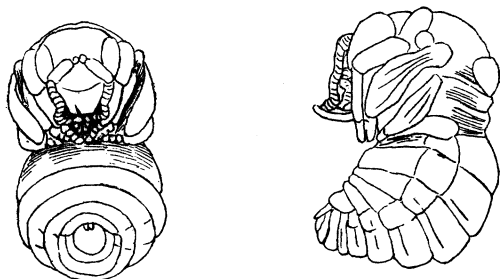


Fig. 12. *Bombus fervidus*. Pupa.

Bombus vagans.

Nesting-habits, Larva and Pupa.—In the empty cells there were no larvæ or eggs to be found. In the bottom the sides a little way up were covered with a thin layer of meal or pollen which had been placed in them by the queen, and this thin layer of refuse left had been pressed to the side of the cell by the body of the fully-fed larva which had rejected it. In one empty cell there was a considerable quantity of pollen, which was exceedingly fine, and under high powers presented a spherical shape, the surface being thickly punctured.

In the twelve workers there was no remarkable variation in size, such as was observed in another colony of pinned bees, undoubtedly of the same species. The single male was of the same size as the worker; it slightly exceeded some workers in size, but was smaller than some others; among a set of alcoholic specimens it could not at first glance be distinguished from the workers; there is no difference in the length of the maxillæ or of the labial appendages.

From the nest which Mr. Putnam found in an old stump under a barn, August 15, he took only fifteen adult bees, viz., one male, two females and twelve workers; but the number of bees then constituting the

colony could be estimated by counting the empty cells. These were wanting in the upper third, or rarely the upper half, which had been eaten away by the bees to allow the occupants to escape; the edges being rough and irregular. Some of the cells were nearly all gone, three-fourths of some of them having been removed; these were situated on the sides of or nearly beneath the bunches of small cells which surrounded the single female or queen cell.

At this date there were 58 empty cells, hence the colony, if all were alive, was of course composed of that number of individuals; of these all were workers except a single male and two females.

Larva.—The larvæ are easily distinguished from those of *B. fervidus* and *B. separatus*, which is the more unexpected, since the two last named species agree so closely after the specimens compared have been in alcohol. The head is considerably smaller, nearly one-fourth so, than in *fervidus*, while the transverse raised bands across each ring are much thicker, and the lateral raised pleural lines are much more prominent than in *B. fervidus*, thus making the under side of the body appear flatter and the upper side more convex than in *fervidus*. The whole body is more lunate, compact and blunter at the extremity than in *fervidus*. Such are the differences in comparing twenty larvæ with an equal number of those of *fervidus*. Whether these differences are constant, and have been stated correctly, future study will prove. The sizes of the different stages of growth correspond very exactly with those of the equivalent stages in *fervidus*.

Eggs.—The eggs of this and all the species when compared do not differ, and if they were all intermingled, the species could not be picked out.

Pupa.—Comparing some (eight) ♂ semipupæ with an equal number of ♀ semipupæ of *B. fervidus*, there are no differences, not even in the tip of the abdomen.

Compared with the male of *fervidus* it is very considerably smaller and slenderer, the abdomen being sensibly more produced towards the more acute tip and the limbs are throughout more slender. The head is shorter and broader. The second joint of the antennæ is longer, passing beyond the eyes, where in *fervidus* they do pass beyond the lower angle and outer edge of the eyes. The maxillæ and lingua are shorter than in *fervidus*, being just as described in the worker pupæ of *B. separatus*, and are unitedly narrow, as in the last named species. The limbs are no longer, but all the joints are considerably narrower than in *fervidus*. Here, as in the other sex, the genital armature does

not differ materially in the two species compared. Perhaps the lateral pair of stylets are shorter, while the inner mesial parallel stylets are a little longer, though these differences are only adopted provisionally. Length of ♂, .44; width, .24 inch.

Both the ♀ and ♂ are of the same size (the latter only .02-.03 less) and agree much more closely with the same states in *fervidus* than does the ♂. Still, however, the body and limbs are a little more slender, the mouth parts are shorter, and the head broader than in *fervidus*.

Average length of worker pupa .43; breadth .23 inch.

Average length of female pupa .58; breadth .28 inch.

One under-sized individual is .32 × .18.

***Bombus separatus* Cresson.**

Nest, Larva and Pupa.—This nest was found by Prof. Putnam, July 23d, under the grass, in a deserted field-mouse's nest, in a rather damp situation. The active members of the colony were ten bees (no males among them), which were captured and pinned. On examining the nest I found that it consisted of 36 cells, of which all but 23 contained females and workers; of the remaining 13, which were all worker cells, two contained pollen (or honey) closely packed; the rest were empty and with the tops eaten off. The other 23 contained one worker in the semipupa stage, ten worker larvæ, one female larva, five semipupal females and four female pupæ. There were also 20 eggs and 12 young larvæ in the masses of bee head which were found attached to the sides or top of the queen cells, as shown in Fig. 13. When placed on the top of a cell the bee head formed a rounded mass, which, on be-

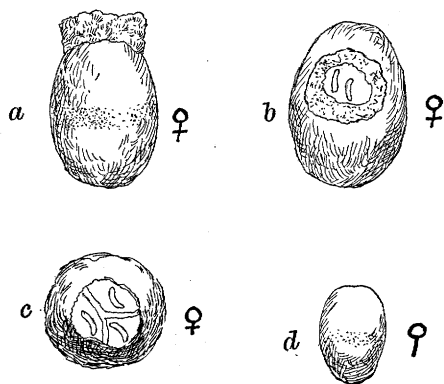


FIG. 13.—*Bombus separatus*. *a*, cell with mass of pollen on top; *b*, one with pollen enclosing two eggs; *c*, view from above; *d*, worker cell. (Author del.)

ing opened, disclosed four partitions, two at each end of the slightly ellipsoidal area, with two at each side; the two lateral ones being widely separated, but the other two only separated by a thin partition. These are walled in by the queen bee after she has placed one or two eggs in each cell. Out of this mass of food the young larvæ when hatched begin by eating the food to gradually construct their cells in the manner observed and described by Professor Putnam. One would suppose that there would be one larva only in each compartment, but on the contrary I found two young larvæ in each. The eggs are the same as those of *B. fervidus*, no specific differences being discernible.

The larvæ were young, none being more than one-third the size of the workers in the semipupa stage, while the single female larva was of full size.

The young larvæ compared with those of B. fervidus.—They are so similar that it would be impossible to distinguish them. The larvæ of *B. fervidus* differ more among themselves than do those of *B. separatus* and *B. fervidus*? The size of the head and proportions of the body, are the same. The thickened portions of the segments are also much the same, though there is a difference in that this portion is a little thicker in *B. fervidus*, but this is not a constant character. Indeed, in comparing two larvæ of the two species mentioned, each nearly a quarter of an inch long, I can see no difference between them.

Pupa of Worker.—It can best be described by comparing it with that of *B. fervidus*, of which I had the greatest number of specimens. Besides being a little smaller, it differs in form, being more plump, nearly a line shorter, and slightly broader. The head is more triangular, being shorter and at the same time proportionately broader. The eyes converge slightly towards the mouth. The antennæ and clypeus and labrum, as well as the ocelli, show no appreciable differences.

The genital armature and tip of the abdomen in general do not, contrary to our expectation, afford good specific distinctions. We see, therefore, that the pupæ differ specifically in their size and proportions, while the perfect bees have added the more readily recognized differences in coloration and hairiness.

Of the ten worker pupæ two were a little larger, almost in the subimaginal stage, and dark, and belonging apparently to the second brood of workers.

Average length of 2 worker pupæ of the first brood, .50; breadth, .32 inch.

Average length of 8 worker pupæ of the second brood, .46; breadth, .28 inch.

Female Pupa.—The pupæ of the females are equal in size to that of

the largest *B. fervidus*, and the female pupæ differ in the same characters as already given for the worker pupæ. In this species, as in all other bees and wasps, the only external difference between the workers and females is that of size.

The female pupæ were all of one and the same size, white and naked.

***Apis mellifica* Linn.**

Larva of Worker.—I am not aware that a careful and comparative description of the larval honey-bee worker has been published. The following descriptive comparisons have been made with larva of the bumble bee:

Closely resembles larva of *Bombus*, but the body is shorter, broader, flatter, with the head less prominent than in *Bombus*. The body is much rounded towards the head and abdomen, tapering very equally at both ends; the segments but slightly convex, while the lateral region is less prominent than in *Bombus*, less so than usual; and the posterior portion of the segments is less thickened than usual. On the anterior part of the back (tergum) of each ring is a broad sublunate area, behind which, and especially on the sides, the ring becomes more convex. The tip of the abdomen is subelliptical, being round, but longer than broad; the tergites and sternites not well marked. It, however, resembles the larval *Bombus* quite closely. Genitals well marked on eighth ring at front edge, appearing as two minute parallel slender tubercles, also a pair on the ninth and tenth segments less distinctly marked, but a little larger. The head is of about the same proportion to the rest of the body as in *Bombus*; it is a little longer than broad, the front not very convex. Eye-ring not very full. The median line between the eyes is deeply impressed. The antennæ each form a deeply depressed minute tubercle on each side of the base of the clypeus. Supraclypeal area indistinctly marked. The clypeus is square, as long as broad, much longer and narrower than in *Bombus*. The labrum is broad, bilobate, covering the ends of the mandibles; broader and more transverse than in *Bombus*. The maxillæ are rather slenderer than usual, subacute, ending in a minute acute spine. Labrum as usual, ending in a slightly chitinous transverse ridge. Mandibles cylindrical, acute, ending in a single point, more fleshy, and more like the maxillæ than usual.

Position of Larva.—It is doubled on itself in the bottom of the cell, being more doubled than in *Bombus*, and with a softer, thinner skin. The cell of the semipupa is closed over, and the body of the latter is elongated and extended along the length of the cell. There is nothing in the shape of the larva to justify the inference that *Apis* is not a higher genus, more specialized, than *Bombus*.